

Yield and Quality of Green Asparagus Produced by Forcing Culture

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Summary

Seeds of *Asparagus officinalis* cv. "Mary Washington 500 W" were sown in spring, 1974, and plants grown were transplanted at the density of 330 or 660 plants a^{-1} inside a plastic house, then crowns were covered with plastic tunnels for forcing during period of 90 days in winter. The treatment was started from either December or January. Spears were harvested when they reached to the height of 20 cm.

Number and fresh weight of spears harvested increased with the rising of temperature and showed little difference among plots with the same plant density regardless the starting date of the treatment. Total amount of yield in plots with higher density showed about 1.6 times more than in lower one. Dry matter ratio in a spear showed to be high in a distal half, and the ratio decreased proportionally with the reduction of days required for spears to reach 20 cm long after sprouting on the soil surface. Firmness of pith of spear ranged from 3 to 8 $\text{dyne/cm}^2 \times 10^5$ and the most tender part was at 10-15 cm below the tip. This part coincides with the part at which spears are snapped. Firmness, which was measured by the penetration force test, tends to decrease with the increment of spear diameter, and the highest correlation between the firmness and the diameter was seen in the proximal side of the snapped part.

Introduction

High production of asparagus spear in the temperate region of Japan may be attained by the forcing culture method. Since the asparagus plant shows continuous growth under the temperature condition from 5 to 30°C and the optimum growth is found under 20-25°C. Vigorous spears are possible to obtain under field cultivation in the temperate region of Japan from April. Nevertheless, commercial asparagus production has been concentrated in the northern Japan where climate is cooler and, consequently, harvest delays until May or to June. A reason for this is to avoid the infection of diseases such as stem blight and violet rot, which prevail in the temperate region during the season from summer to fall. However, recent development of chemical control method of the diseases and breeding of new cultivars has made commercial production of spears by the forcing culture possible in the temperate region.

Practice of farmers to harvest the highest amount of production from their cultivation tends to make the asparagus quality not always uniform in several biological factors. Particularly, those factors concerning asparagus produced with the forcing culture in the temperate region are as follows; age of spears, thickness, length and fresh weight. For the market purpose harvest of young spears are requested. Lateral buds of spears must be undeveloped, or at most, spears have only small buds which have just appeared slightly from the bract-like leaves. Also required are spears which are thicker than about 5 mm in diameter and shorter than 25 cm in length. Weight of a bundle of spears, which consists of 3 to 10 spears, must be more than 200 g.

In this paper, the authors will deal with the quality of asparagus spears produced with the forcing culture which is carried out in the temperate region of Japan. The results indicate a possibility of producing good spears which may meet the quality required for market.

Materials and Methods

Seedlings of *Asparagus officinalis* cv. "Mary Washington 500 W" which were sown on Jiffy pots in spring, 1974, were transplanted to soil inside a plastic house in February, 1975. As shown in Fig. 1, plants were arranged in single or double rows on a soil ridge of 1 m wide, and 4 plots were made within an area of 8×4 m. Distance between plants was made to 0.3 m.

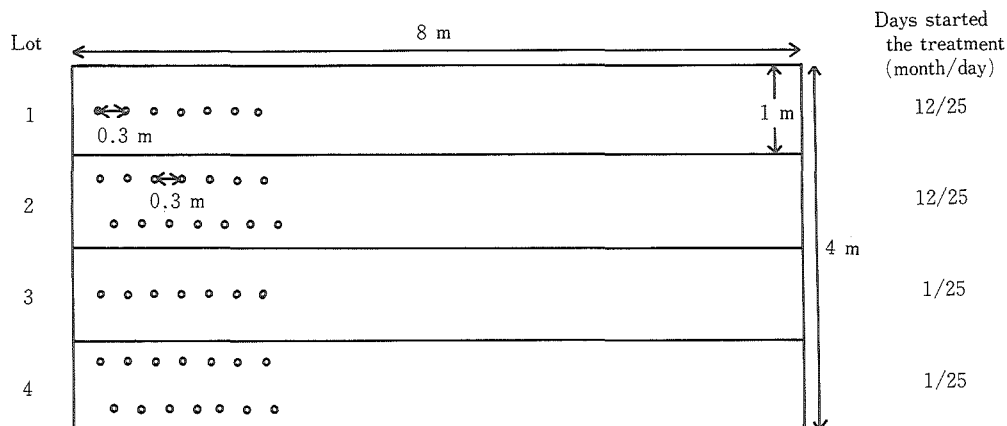


Fig. 1. Design of the arrangement of plants in the experiment lots and days started the forcing treatment. Individual plants indicated by a circle and were subjected to the treatment from the day indicated on the right.

Plant density of these single and double rows was equivalent to 330 and 660 plant a^{-1} , respectively. For studying the quality, spears which had diameter over 5 mm and were younger than the stage 2 (see Fig. 2) were selected from the all of the spears harvested in 1978. Harvesting was made daily and each spear was weighed shortly after the harvest. Both soil and air temperature inside the plastic tunnel, sprouting and harvesting date and fresh weight were recorded. In order to a detailed studies of spear quality, quality determining factors, such as diameter, development stage and the length from the tip to the snapped point were studied in all of the spears harvested in 1978 and 1979. Firmness was measured at the center of the cross section by using an Iio electric Co. M-3-1 AR fitted with a spring balance for 400 g and the plunger of 3 mm in diameter.

Results

Although the most of the spears which are on the market in Japan is about 25 cm in length, in the present study spears were harvested whenever they grew into 20 cm regardless the aging, since spears reached 25 cm long have rather big amount of tissue that thought to be not edible. The diameter varied from 2 mm to over 30 mm. Since the development stage of the lateral bud is thought to be a good indication of aging in asparagus spears as shown in Fig. 2, they were classified into the following 4 development stages: 1, spears with very young or undeveloped buds; 2, spears with buds that has just appeared slightly from the bract-like leaves; 3, spears with buds that protruded out of the bract-like leaves, and 4, those with lateral buds which are grown up to shoot. The yield of spears from the 4 years-old plants and both soil and air temperature inside the tunnel were shown in Fig. 3. Harvesting of first spears delayed

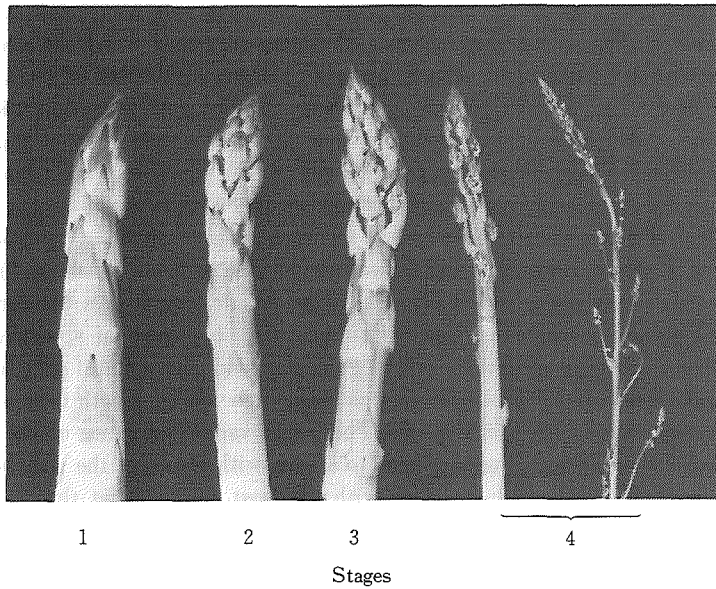


Fig. 2. Development stages of lateral buds. Buds are very young or undeveloped in the stage 1, and appear in 2, and through the stage that they protrude out of bract-like leaf in 3, develop into a shoot in the stage 4.

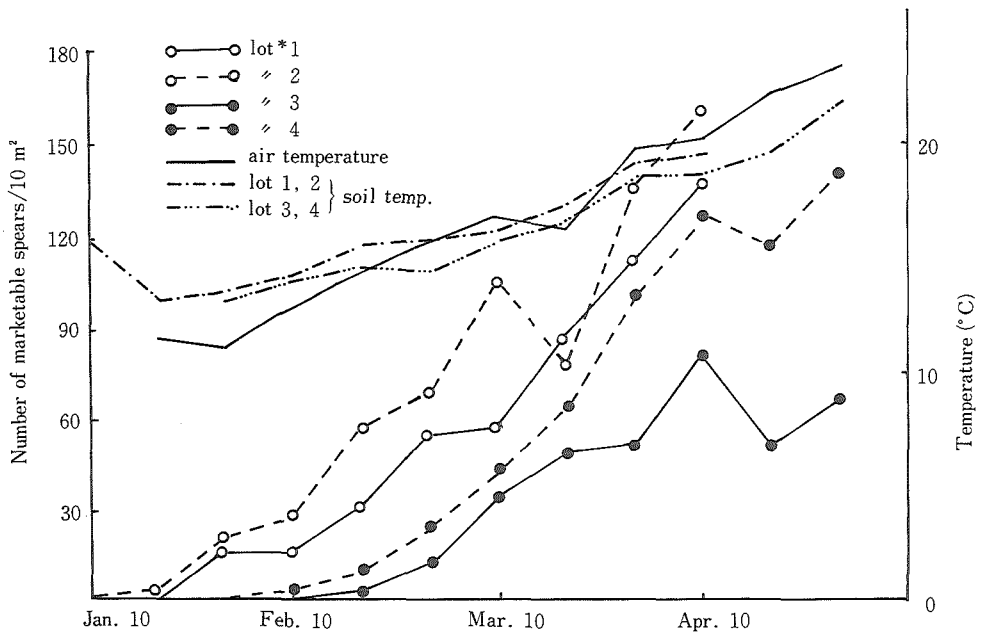


Fig. 3. Number of spears harvested within 90 days in each lot after the first harvest and the air and soil temperature inside of plastic tunnel covered a soil ridge. * see Fig. 1.

from 20 to 30 days after the start of the treatment, since spears appeared shortly after covering the ground with plastic tunnel. Number of spears harvested within 10 days increased as the temperature gradually rised, although number come out was very small during the first month. As shown in Fig. 4, similar tendency of cumulative fresh weight of spears was seen among the lots with the same plant density regardless the starting day of the treatment, and the total yield in the high-density plot showed about 1.6 times more than in the less density one. Percentage of dry matter was usually higher in a distal half than in a proximal half, although values showed gradual reduction from 10 to 8% in a distal half and from 8.5 to 6.5% in a proximal half during an experiment period from February 20th to May 5th (Fig. 5). Gradual shortening of days that are required for spears to reach 20 cm long after sprouting on the soil surface by rising of temperature in spring showed almost proportional reduction with dry matter content of spears. Those harvested on March 1st had been taking 8 days to reach 20 cm, and 4 days for the material harvested on April 30th (Fig. 5). Firmness of spears is also one of the major factors concerning the quality. It is generally said that a distal part from a snapped point shows tenderness and palatability. In this connection, distal length from a snapped part of spears were studied and shown in Fig. 6. The length varied depending on the temperature, and it was changed from 10 cm long in March to 13 cm with rising of the soil temperature by May 10th. This length may nearly coincide with the most tender point that is found in part

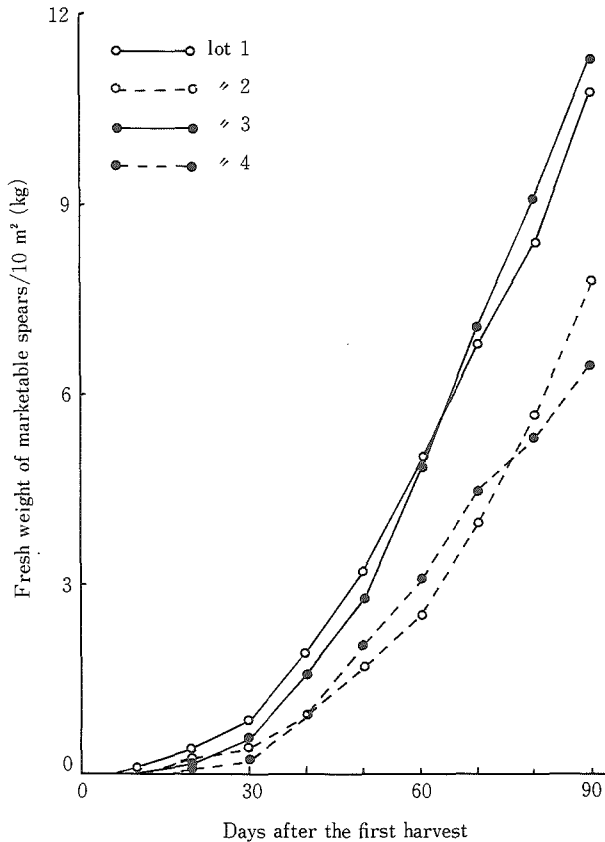


Fig. 4. Cumulative fresh weight of the spears harvested in each lot.

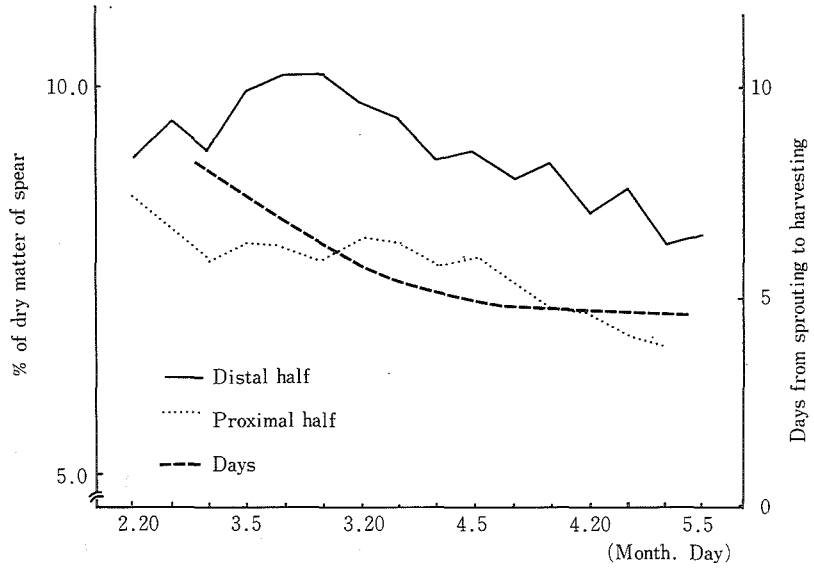


Fig. 5. Changes of dry matter ratio in distal and proximal halves of spears and days required from sprouting to harvesting.

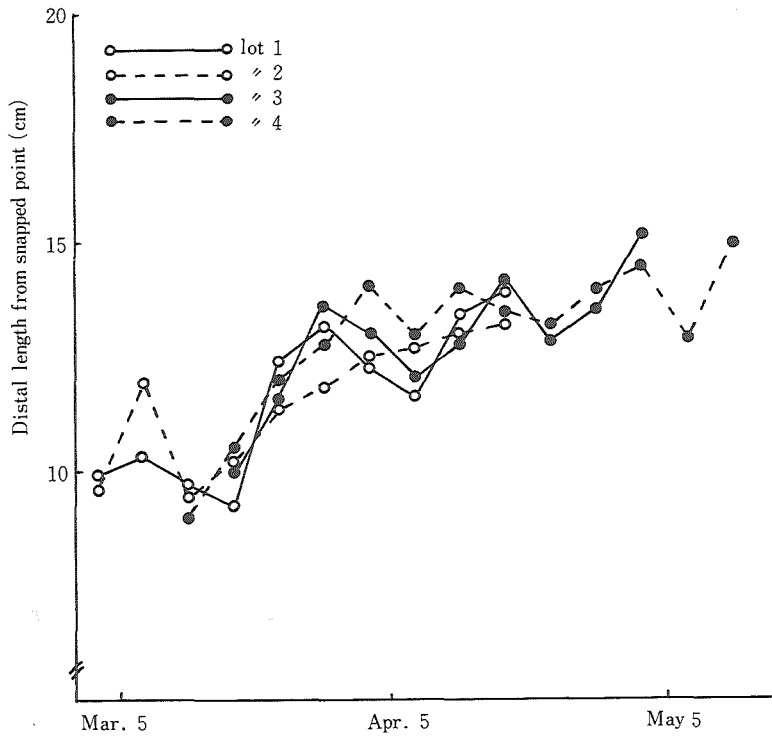


Fig. 6. Change of distal half length from the snapped point of spears.

10–15 cm below the tip (Fig. 7). Firmness of pith was measured with the penetration force, and it was ranged from 3 to 8 dyne/cm²×10⁵. Spears of 15–7 mm or 7–5 mm in diameter were tender showing an order of points at 15, 10, 20 and 5 cm or 10, 15, 5 and 20 cm from the tip, respectively (Fig. 7). Firmness tended to be negatively correlated with the increment of diameter in the materials harvested in 1979 (Fig. 8). High negative correlation, $r = -0.375$, was seen between the diameter and the firmness in the tissue of the proximal side of a snapped point. In the distal side of the point, $r = -0.233$ was obtained, and at 10 cm below the tip, it was $r = -0.218$. Spears with large diameter are usually less fibrous (on a percentage basis) than thin spear¹⁴⁾, and this correlation coincides with the present study.

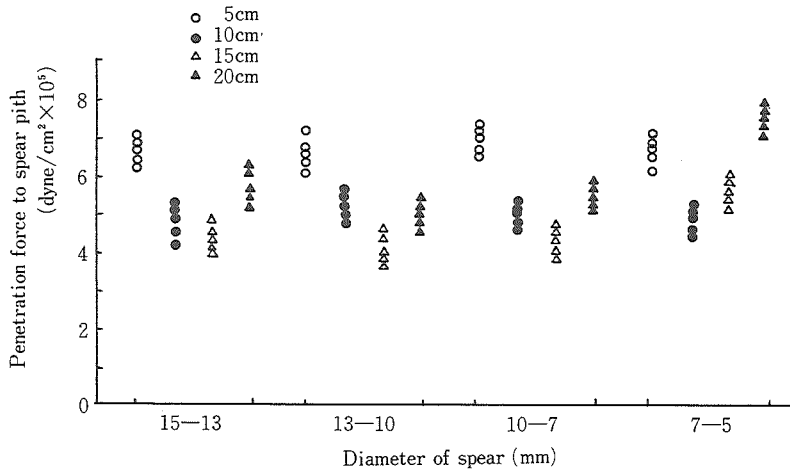


Fig. 7. Penetration force to spear pith tissue at 5, 10, 15 and 20 cm below the tip.

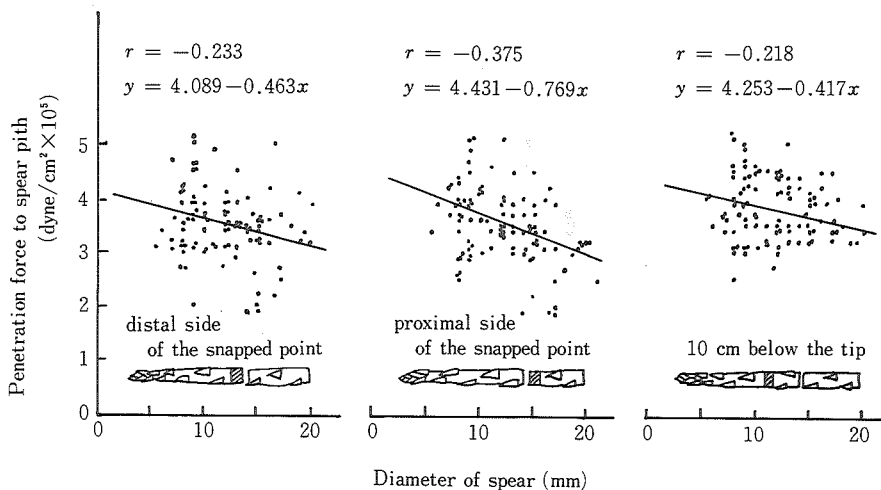


Fig. 8. Correlation between penetration force to pith and diameter of spear.

Discussion

The yield, harvesting time and quality of spears are particularly important factors in the forcing culture of asparagus. Usually yield depends on the plant density. In the present study, when the number of plants transplanted to an unit of area was double, 1.6 times of yield were resulted. Plants are generally planted 1—1.5 m apart each other in a ridge of 1 m wide in cold and even in temperate region^{4,11}. High density such as 330 or 660 plants a^{-1} did not result high yield in the cultivation of cold region where good spears are continuously produced for more than 15 years¹¹. In the temperate region, plants younger than 3 or 4 years-old are planted with the density of 330 or 660 plants a^{-1} and then leave space between plants by removing plants, and renewing plants within a period shorter than 15 years is required for avoiding missing of crowns by diseases infection or wasting by harvesting much spears for long period within a year.

Harvesting time in forcing culture is desired to be as early as possible after the treatment, and it is usually tried to start from 20 to 30 days after the beginning of treatment. Reason for this may be that the crowns used were in the dormant state from December to January⁹. In this study, number of spears sprouted increased gradually, probably due to gradual disappearance of the dormancy, as the temperature rises. If the dormancy is overcome by chemicals such as ethrel, cytokinin or thiourea^{2,3,7,15}, the sprouting begins sooner after the treatment.

The quality of spears harvested from these densities was about the same level with those from the standard culture (MATSUBARA, unpublished). Asparagus quality is usually determined by analysing chemical substances, such as vitamins, inorganic substances, sucrose, starch, protein and amino acids^{9,10,11}, and by measuring fiber content^{1,5,6,12,13,14}. Firmness of spear is comprised in the quality as one of the most important factors. It differs between boiled and fresh materials. The "fork test"¹⁰, which examines whether a spear can be cut with a fork or not, is one of the tests to measure the firmness. It is only useful for boiled materials, and the result is not quantitative. In the fresh materials, firmness is measured quantitatively with penetration force test and differs depending on the kinds of tissue, such as epidermis or pith, spear age and also the direction adding force. Any positive correlation has not been observed when the force was added downwards on epidermis tissue of a lying spear (MATSUBARA, unpublished). Rather a negative correlation between a spear diameter and firmness was found at the center of the cross section of pith tissue. This penetration force test is also related with the age of part of a spear. With a spear of 20 cm long, a part around 15—10 cm below the tip was the most tender, and this part coincided with the snapped part, which was distributed around 10—13 cm below the tip. Snapped part may depend on the fiber content. Fiber content in 5 sections of a spear studied in 9 cultivars was reported as follows; the 10 cm from the tip (0.111%), 10—12.5 cm (0.186%), 12.5—15 cm (0.196%), 15—17.5 cm (0.384%) and 17.5—20 cm (0.725%)¹⁴. The result may show that the fiber content differs significantly at about 15 cm distal section from the remaining proximal part, and in the part of 15 cm may tend to snap. In the present study, the part around 10—13 cm below the tip coincides the changing point of the fiber content.

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促成栽培で生産されたアスパラガスの収量と品質

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アスパラガス‘メリー・ワシントン 500W’を1974年播種し、翌年ビニールハウス内に330又は660本/アールの密度で定植した。毎年12月25日又は1月25日よりビニールトンネルをかけ促成栽培を行い、若茎が20 cmになった時、収穫した。

1978年の収穫をみると、本数・新鮮重とも温度の上昇と共に増加し、トンネル被覆時期に関係なく植付密度の同じ区で同じになる傾向がみられた。総収量は高密度区で1.6倍となった。若茎中の乾物率は基部より先端部で高く、萌芽から収穫までの日数とほぼ平行して2月末から5月にかけて減少した。

若茎のずい組織の貫入抵抗は、3—8 $\text{ダイン}/\text{cm}^2 \times 10^5$ のはんいであり、最もやわらかい部分は先端部から10—15 cm下のところであった。この部分は手折りの部分(先端部より10—13 cmのところ)とほぼ一致する。又、貫入抵抗は若茎径が大きいほど減少し、手折り部でこの相関が最も高かった。